TECHNICAL MEMORANDUM

Monitored Natural Attenuation for Groundwater at the Quendall Terminals Superfund Site

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Introduction

The purpose of this technical memorandum is to provide documentation that supports inclusion of monitored natural attenuation (MNA) as a remedy component for Feasibility Study (FS) remedial alternatives that treat or remove known principal threat waste (PTW) at the Quendall Terminals Superfund Site.[1] In the FS (Aspect and Arcadis, 2016), MNA is retained as an applicable technology and considered a process option for groundwater at the site:

> *While monitored natural attenuation may not be effective at achieving the RAOs[2] as a stand-alone technology, it may be effective as a polishing step when combined with other treatment options.*

Though retained in the FS, MNA was not included explicitly in any of the proposed remedial alternatives. Based on Region 10's presentation of the FS alternatives, the National Remedy Review Board recommended that the Region's decision documents provide supporting evidence for MNA consistent with Agency guidance. In response, this memorandum provides supporting information for including MNA as a remedy component in the Quendall Operable Unit 1 (OU1) Proposed Plan that is consistent with OSWER Directive No. 9200.4-17P, April 21, 1999, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, And Underground Storage Tank Sites.*

Supporting exhibits from the Remedial Investigation (RI, Anchor QEA and Aspect, 2012) and the FS are provided in Appendix A.

OU1 Alternatives Considered Suitable for MNA

The FS included the following alternatives:

- Alternative 1 – No Action
- Alternative 2 – Containment: permeable soil capping

[1] EPA has determined that coal tar and creosote dense nonaqueous phase liquid (DNAPL) and DNAPL-impacted soil (that is, either oil-wetted or oil-coated) such as those present at the Site are to be considered PTW based on the large mass present, the mobility of the DNAPL, and the toxicity of the chemicals found in the DNAPL.

[2] RAOs = remedial action objectives. The RAO for groundwater is to restore groundwater to its highest beneficial use (drinking water) within a reasonable timeframe.

- Alternative 3 – Targeted PTW Solidification (Railroad Tank Car Loading Area [RR] and Former May Creek [MC-1] DNAPL Areas): targeted treatment of two areas of deep PTW via in situ solidification (ISS), passive groundwater treatment, and soil capping
- Alternative 4 – Targeted PTW Removal (Quendall Pond – Upland [QP-U] DNAPL Area): targeted treatment of PTW via removal and/or offsite disposal, passive groundwater treatment, and soil capping
- Alternative 4a – Targeted PTW Solidification (QP-U, RR, and MC-1 [Boring Log MC-1] DNAPL Areas): targeted treatment of two areas of deep PTW via ISS, passive groundwater treatment, and soil capping
- Alternative 5 – Targeted PTW Solidification (RR, MC [Former May Creek], and QP-U DNAPL Areas and DNAPL ≥ 4-Feet in Thickness): targeted treatment of multiple areas of PTW via ISS, passive groundwater treatment, and soil capping
- Alternative 6 – Targeted PTW Solidification (RR and MC DNAPL Areas and DNAPL ≥ 2-Feet in Thickness) and Removal (QP-U DNAPL Area): targeted treatment of multiple areas of PTW via ISS and targeted removal/offsite disposal of PTW, passive groundwater treatment, and soil capping
- Alternative 7 – PTW Solidification: treatment of all PTW via ISS and soil capping
- Alternative 8 – PTW Removal: treatment of all PTW via removal/onsite *ex situ* thermal treatment and soil capping
- Alternative 9 – Solidification and Removal of PTW and Contaminated Soil: treatment of all PTW and contaminated soil via ISS or removal/onsite *ex situ* thermal treatment, and soil capping
- Alternative 10 – Removal of PTW and Contaminated Soil: treatment of all PTW and contaminated soil via removal/onsite *ex situ* thermal treatment, and soil capping

Following completion of the FS, EPA added an additional alternative for OU1, Alternative 7a, which is *in situ* treatment of all PTW via an innovative thermal technology, Self-sustaining Treatment for Active Remediation (STAR), and soil capping (EPA, 2017). STAR would be used to treat the area with known PTW[3], and a soil cap would be placed where soil chemicals of concern (COCs) exceed preliminary remediation goals in surface soil, to maintain protectiveness.[4] **Alternative 7a is EPA's Preferred Alternative.** Alternative 7a differs from Alternative 7 in that it replaces ISS with the STAR technology.[5]

Consistent with EPA guidance (EPA, 1999), MNA is only considered suitable for alternatives that include active remediation measures to address the known contaminant source (PTW). Therefore, MNA will be added to Alternatives 7, 7a, 8, 9, and 10 in the OU1 Proposed Plan. MNA will not be added to Alternative 2, which does not address any PTW, nor will be it added to Alternatives 3 through 6, which leave substantial PTW in place.[6]

COCs for groundwater include benzene, naphthalene, carcinogenic polycyclic aromatic hydrocarbons (cPAHs) represented by benzo(a)pyrene, and arsenic. MNA will be primarily applicable to benzene and naphthalene. Benzo(a)pyrene and arsenic are essentially immobile and not expected to degrade significantly over time; however, the extent of the benzo(a)pyrene plume is closely associated with the occurrence of DNAPL, therefore if the DNAPL source is treated or removed, then it is anticipated that the benzo(a)pyrene plume would also be largely treated or removed. Elevated arsenic concentrations in groundwater may be caused, at least in part, by mobilization of naturally occurring arsenic under

[3] The target treatment area for STAR is identical to that for Alternatives 7 and 8.

[4] As noted in the FS, it is anticipated that future development would also raise the overall grade of the Site (i.e., requiring import of clean fill).

[5] Per OSWER Directive 9200.4-17P: "EPA also encourages the consideration of innovative technologies for source control or "active" components of the remedy, which may offer greater confidence and reduced remediation time frames at modest additional cost."

[6] Alternatives 3 through 6 include passive groundwater treatment via a permeable treatment wall.

reducing conditions, which occur in areas of soils containing DNAPL, dissolved-phase hydrocarbon contamination, and naturally high levels of organic carbon (e.g., peat) (Aspect and Arcadis, 2016). If the DNAPL source is treated or removed, reducing conditions would change and thus likely make arsenic less mobile.

Site Characterization Data Supporting MNA

Two key lines of evidence support the addition of MNA as a remedial component for OU1 alternatives that address the known contaminant source.

Benzene and naphthalene plumes are currently stable. The primary source of contamination, the creosote manufacturing facility, started operations in 1916 and stopped in 1969. The Remedial Investigation (RI, Anchor QEA and Aspect, 2012) states that groundwater monitoring data at Site monitoring wells indicate generally stable levels of DNAPL constituents over the last 20 years.[7] In other words, groundwater plumes continue to the present, but expansion of the size of the plumes appears to have ceased in the 45 years since the facility has stopped operations. The solubility of benzene and naphthalene are a key component to what makes PTW removal a potential successful remedy. These site contaminants have a much greater solubility than some of the other COCs (for example naphthalene solubility is in range of 30 mg/L compared to benzo(a)pyrene in range of 6 µg/L, orders of magnitude less soluble even if it remains in some areas of site). Appendix A of this memorandum includes RI figures showing historical benzene and naphthalene concentrations over time.[8]

The lack of significant seasonal or long-term trends for benzene and naphthalene in groundwater is likely the result of the widespread presence of DNAPL as the primary source of contamination to groundwater. Most DNAPL is located below the water table, in constant contact with groundwater, and thus leaching of contaminants occurs at a fairly steady rate.[9]

Degradation of contaminants is occurring. The RI included a detailed sampling and analysis of groundwater and sediment porewater concentration gradients were performed for the upper 4 feet of sediment in Lake Washington, in the area immediately offshore of the uplands.[10] In addition to porewater analysis for benzene and naphthalene, the sediment porewater samples were also analyzed for several relatively non-reactive “tracer” cations (sodium, potassium, calcium, and magnesium) to help differentiate between chemical/biological concentration attenuation processes that affect Site contaminants and simple dilution with surface water. The results of the evaluation of these data showed significant attenuation (more than two to three orders of magnitude) of benzene and naphthalene as compared to the tracer cations, indicating the existence of biodegradation and/or chemical attenuation processes in the transition zone between groundwater and Lake Washington. Appendix A of this memorandum includes RI figures showing benzene, naphthalene, and tracer cation concentrations with depth beneath the lake. It also includes a figure summarizing these results that was included in the FS.

Site Modeling Results Supporting MNA

Models were developed and documented in the FS to assess the relative effectiveness of FS alternatives. The FS modeling results are used here as a secondary line of evidence for supporting MNA, as the modeling results are considered to carry a significant degree of uncertainty, as compared to empirical

[7] Section 6.1.1.3.3 of the RI Report (Anchor QEA and Aspect, 2012).

[8] Taken from Figures 5.2-7 (benzene) and 5.2-13 (naphthalene) from the RI Report.

[9] Section 5.2.1.1.3 of the RI Report.

[10] Section 6.4.3 of the RI Report.

site characterization data. As noted in the FS, because of the limitations and constraints inherent in the application of predictive models, the results are appropriate for evaluating, on a relative basis, how a particular remedial action may change conditions and how different remedial actions compare.

The FS groundwater modeling results for benzene and naphthalene under Alternatives 7, 8, 9 and 10 indicate that once the DNAPL source is treated or removed, benzene and naphthalene will attenuate over time.[11] The FS groundwater modeling results are summarized as follows:

- Restoration timeframes for Alternatives 7 through 10 range from 14 to over 100 years for benzene, from 46 to over 100 years for naphthalene.
- Within 100 years:
  - Alternatives 7 and 9 are predicted to reduce the benzene plume volume by 97 percent; and the naphthalene plume by 89 and 86 percent, respectively. Alternatives 8 and 10 would each reduce benzene and naphthalene by 100 percent.
  - Alternatives 7, 8, and 10 are predicted to reduce the benzene contaminant mass by 100 percent; Alternative 9 predicted to reduce the benzene contaminant mass by 99%. Alternatives 7 through 10 are predicted to reduce the naphthalene contaminant mass by 100 percent.
  - Alternatives 7 through 10 are predicted to reduce the mass flux of benzene and naphthalene from the uplands to the Lake Washington by 100 percent.

As documented in the FS, EPA views the groundwater model as conservative (e.g., predicting conservative restoration timeframes) for several reasons:

- The baseline (pre-remediation) plumes that the model generates exceed the plume boundaries based on empirical data.
- Given that creosote production stopped in 1969, it is reasonable to assume that the groundwater plumes are in steady state or reducing (i.e., they would not grow to the sizes predicted in the model).

The FS also acknowledges modeling simplifications and assumptions that may under-predict modeling results, primarily residuals from potentially not addressing every occurrence of DNAPL; however, noting that DNAPL residuals would most likely be in thin laterally discontinuous sand stringers within the Shallow Aquifer bounded by relatively impermeable silts/clay, making them relatively low-strength groundwater contamination sources.[12]

Additional contaminant transport modeling conducted to support the FS approximated the mixing and attenuation processes in groundwater beneath the lake. Modeling results showed that undifferentiated abiotic and biodegradation may be important processes affecting the concentrations of the mobile indicator chemicals such as benzene and naphthalene. However, these degradation processes are not expected to have any appreciable effect on the concentrations of less mobile COCs such as cPAHs and arsenic.

Alternative 7a was added as an alternative after the FS and therefore was not included in the FS model; however, it is reasonable to assume that since Alternative 7a destroys the known PTWs, that its performance would be consistent with Alternatives 7 and 8.

[11] The FS groundwater model is contained in Appendix A of the FS Report (Aspect and Arcadis, 2016).

[12] Section 7.1.1.2 of the FS Report (Aspect and Arcadis, 2016) describes modeling uncertainties.

Summary

The following considerations for evaluating if MNA is an appropriate remedy component for soil or groundwater at a given site are from p. 17 of the EPA's MNA guidance (EPA, 1999).[13] A statement regarding Quendall site conditions is included below for each consideration (**bold**). These statements serve to support incorporating MNA in alternatives that treat or remove PTW as the primary remedy component for OU1 (Alternatives 7, 7a, 8, 9, and 10).

1. Whether the contaminants present in soil or groundwater can be effectively remediated by natural attenuation processes.

   As described in previous sections, (1) empirical site data indicate that benzene and naphthalene plumes are currently stable, (2) degradation of contaminants in the subsurface is occurring, and (3) modeling indicates that contaminants present in soil and groundwater at Quendall will attenuate over time, once the DNAPL (the site PTW) source is treated or removed.

2. Whether or not the contaminant plume is stable and the potential for the environmental conditions that influence plume stability to change over time.

   The DNAPL source at Quendall has been in place for 50 years and RI groundwater data indicate the plume is currently stable. Once the DNAPL source is treated or removed, empirical site data and modeling indicate that the residual plume volumes will be significantly reduced and will attenuate over time.

3. Whether human health, drinking water supplies, other groundwaters, surface waters, ecosystems, sediments, air, or other environmental resources could be adversely impacted as a consequence of selecting MNA as the remediation option.

   None of these resources would be adversely impacted as a consequence of selecting MNA as a remedial component in conjunction with treatment or removal of the DNAPL source. There are no current drinking water supplies being affected, institutional controls will be used to prohibit use of groundwater until groundwater is restored to its highest beneficial use, and the OU2 remedy at Quendall includes an isolation cap in the nearshore area of the site, to protect sediment and surface water from residual contamination that may continue to discharge to Lake Washington.

4. Current and projected demand for the affected resource over the time period that the remedy will remain in effect.

   There is currently no demand for groundwater present beneath the Quendall Site and this situation is not expected to change over the time period that the remedy will remain in effect (also see Item 3).

5. Whether the contamination, either by itself or as an accumulation with other nearby sources (on-site or off-site), will exert a long-term detrimental impact on available water supplies or other environmental resources

   Modeling predicts that treatment or removal of the DNAPL source will significantly reduce the contaminant mass, reduce the plume volume, and mass flux of contamination from DNAPL to groundwater and to Lake Washington (also see Item 3). There are no other nearby sources that are expected to cause accumulation of contaminants over time consistent with the

[13] These considerations are bulleted in the guidance, but are numbered here for ease of cross-reference.

DNAPL source; however, cPAHs are present in Lake Washington sediment at low levels due to anthropogenic activities.

6. Whether the estimated timeframe of remediation is reasonable (see section on "Reasonable Timeframe for Remediation") compared to timeframes required for other more active methods (including the anticipated effectiveness of various remedial approaches on different portions of the contaminated soil and/or groundwater).

   Groundwater modeling included an evaluation of the effectiveness of a pump and treat system for Alternative 10. The analysis indicated that when compared to no pumping, optimized pump and treat is predicted to accelerate the restoration of naphthalene by about 10 percent and would have no effect on benzene restoration. It is unlikely that another remedial technology could make a significant difference in the reduction of the contaminated plume. Therefore, the estimated timeframe of remediation for MNA is considered to be comparable to timeframes for more active methods.

7. The nature and distribution of sources of contamination and whether these sources have been, or can be, adequately controlled.

   Sources of contamination will be controlled via treatment or removal. MNA is only being added to OU1 alternatives that treat or remove the known DNAPL sources, as a follow-on step to address residual groundwater contamination.

8. Whether the resulting transformation products present a greater risk, due to increased toxicity and/or mobility, than do the parent contaminants.

   Coal-tar constituents transform into smaller compounds, with the final non-toxic products commonly being carbon dioxide, methane, and water.

9. The impact of existing and proposed active remediation measures upon the MNA component of the remedy, or the impact of remediation measures or other operations/activities (*e.g.*, pumping wells) in close proximity to the site.

   MNA would be relied on after active remediation work at the site is complete, therefore MNA would not be impacted by other remediation measures (other than the improved conditions from the treatment or removal of the DNAPL).

10. Whether reliable site-specific mechanisms for implementing institutional controls (*e.g.*, zoning ordinances) are available, and if an institution responsible for their monitoring and enforcement can be identified.

    The surrounding community is serviced by public water systems, which depend on potable water sources located outside of the Site area. The use of private wells in the area is limited and those wells are located upgradient of the Site. In accordance with the local zoning ordinances (e.g., King County Comprehensive Plan), new individual private water supply wells will not be permitted within municipal water supply service area boundaries, which include the Quendall Site.

References

Anchor QEA, LLC and Aspect Consulting, LLC (Anchor QEA and Aspect). 2012. *Final Remedial Investigation Report, Quendall Terminals Site, Renton, Washington.* Prepared for U.S. Environmental Protection Agency, Region 10, on behalf of Altino Properties, Inc and J.H Baxter & Company. September. Accessed July 15, 2018. https://semspub.epa.gov/work/10/500010867.pdf.

Aspect Consulting, LLC and Arcadis US (Aspect and Arcadis). 2016. *Feasibility Study, Quendall Terminals Site.* Prepared for: U.S. Environmental Protection Agency, Region 10 on behalf of Altino Properties and J.H. Baxter & Co. December. Accessed July 15, 2018. https://semspub.epa.gov/work/10/100043827.pdf.

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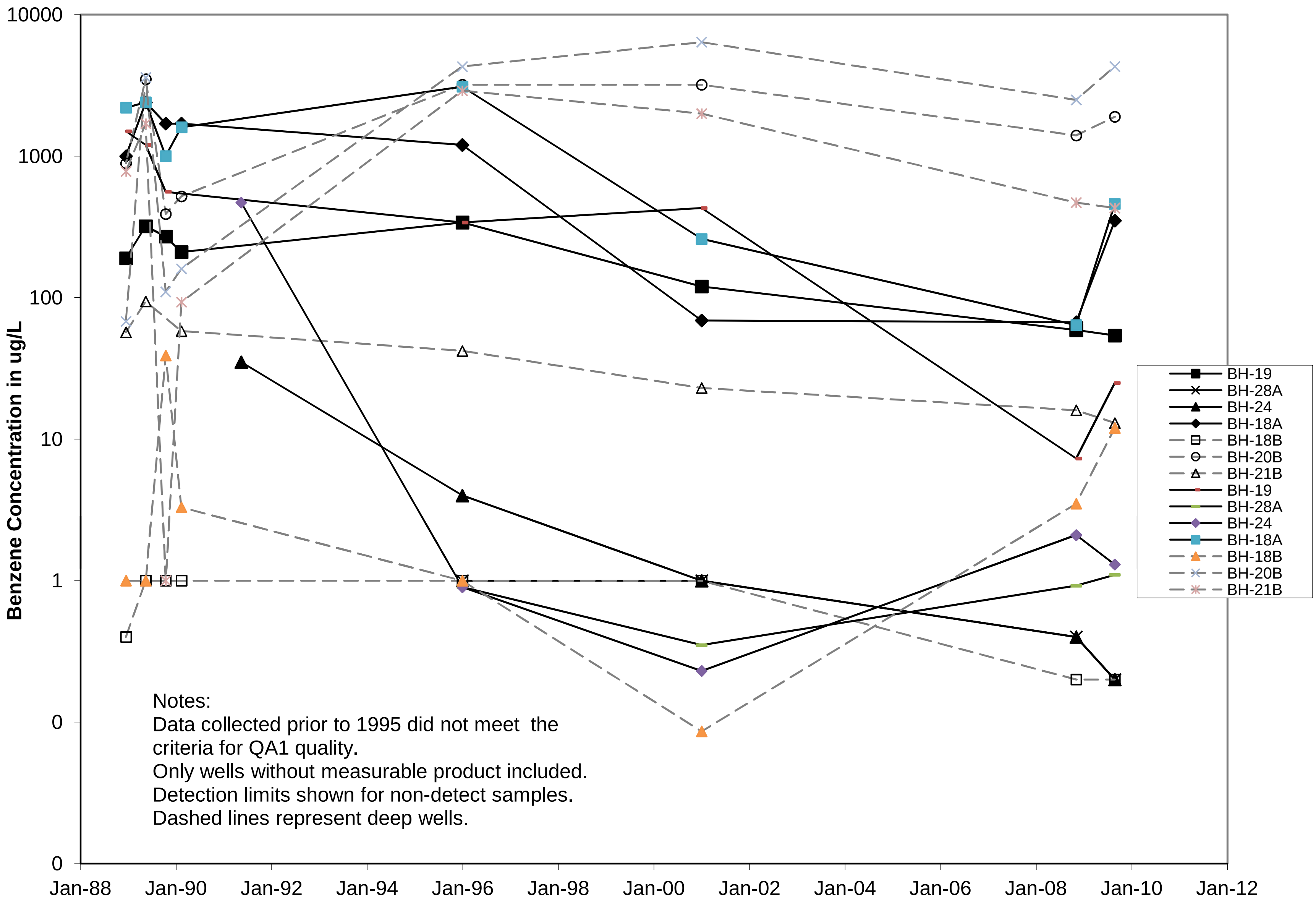
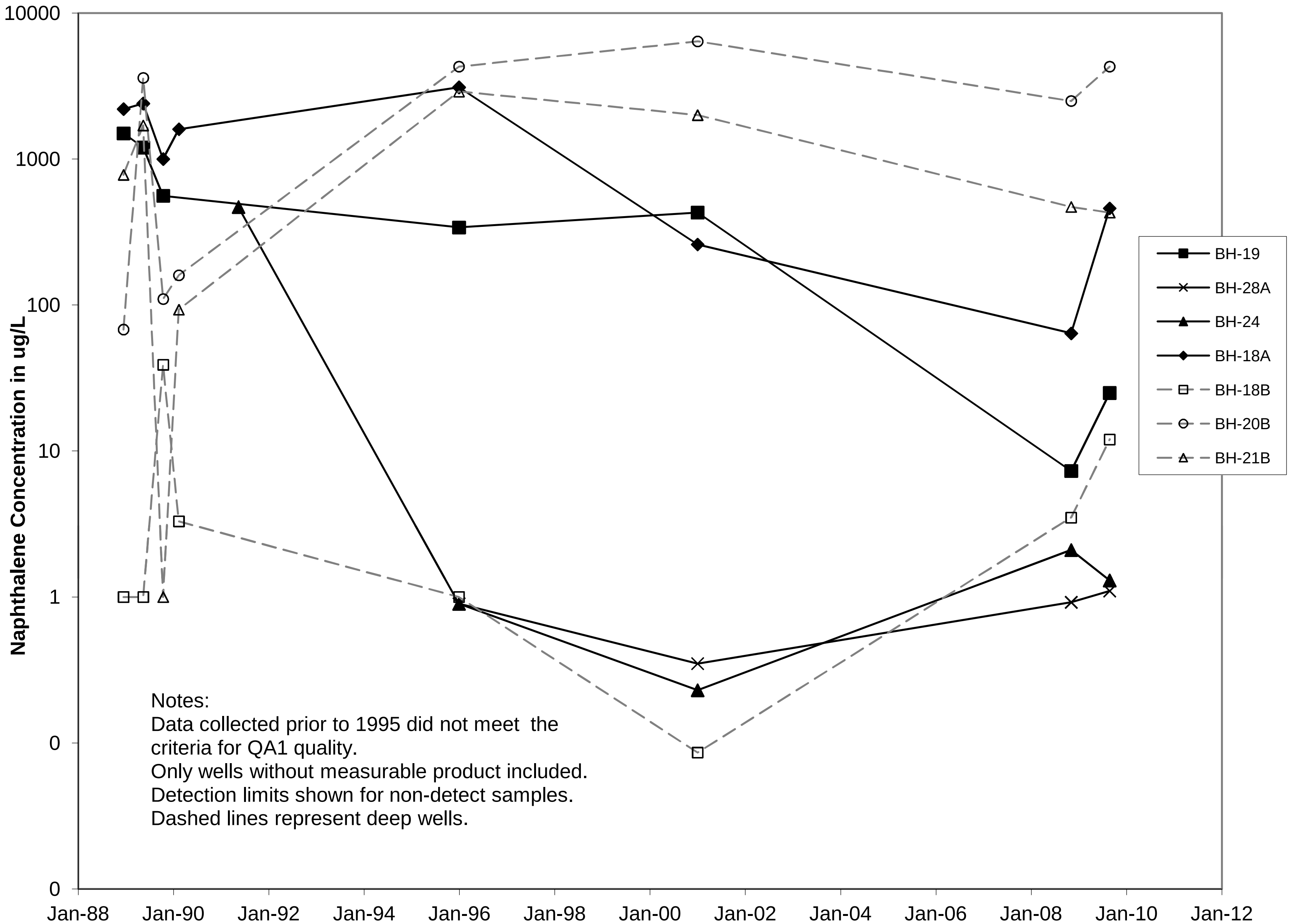
U.S. Environmental Protection Agency (EPA). 2017. Addition of STAR Technology for Quendall Terminal Site. From Kathryn Cerise, EPA Region 10, Office of Environmental Cleanup, to Site File. September 11. Accessed July 15, 2018. https://semspub.epa.gov/work/10/100101660.pdf

Appendix A
Supporting Exhibits



Aspect Consulting
September 2012

Figure 5.2-7
Historical Benzene Concentrations at Shoreline Wells
Final Remedial Investigation, Quendall Terminals



Aspect Consulting
September 2012

Figure 5.2-13
Historical Naphthalene Concentrations at Shoreline Wells
Final Remedial Investigtion, Quendall Terminals

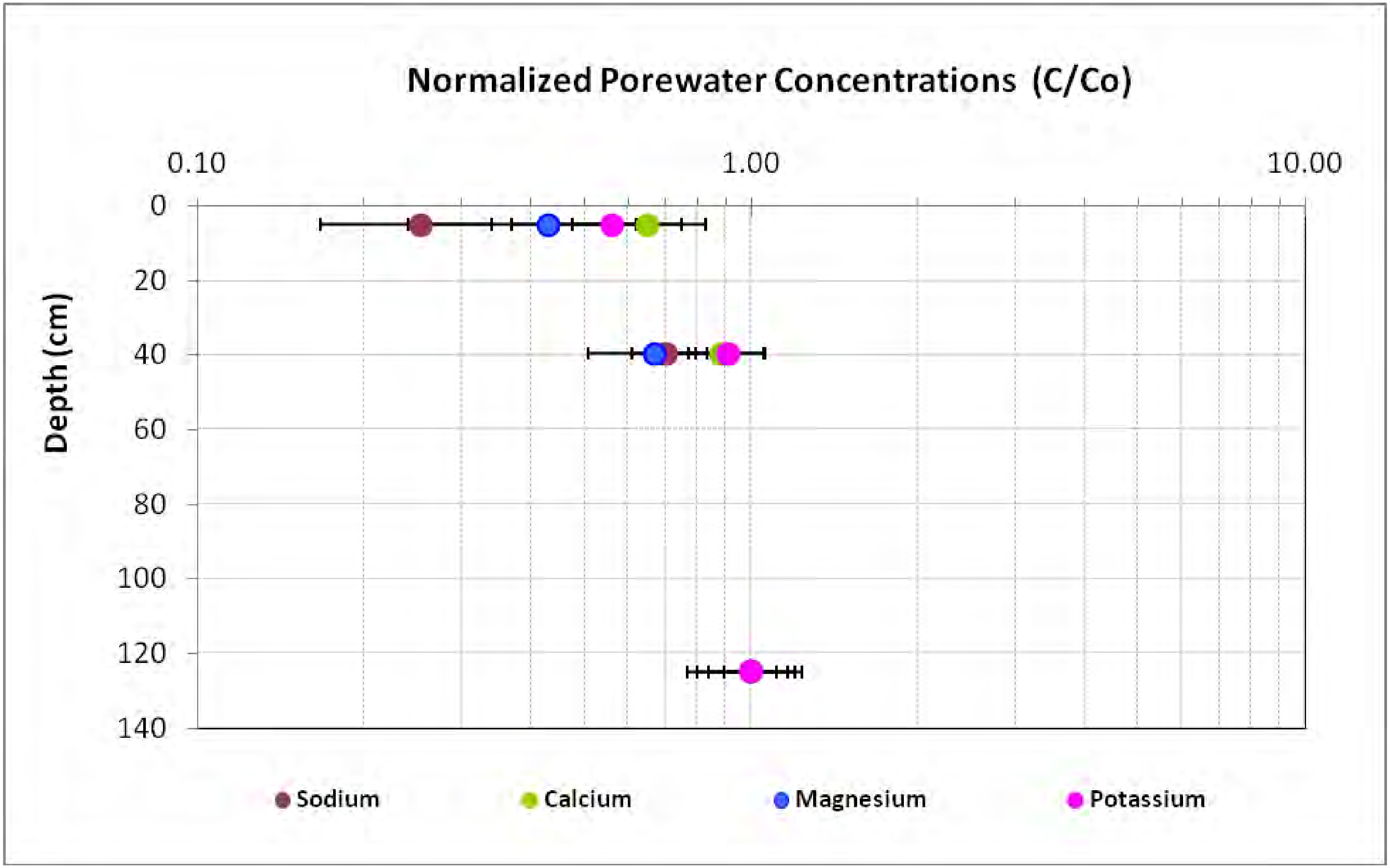


Figure 6.4-5
Cation Calibration Results
Final Remedial Investigation, Quendall Terminals

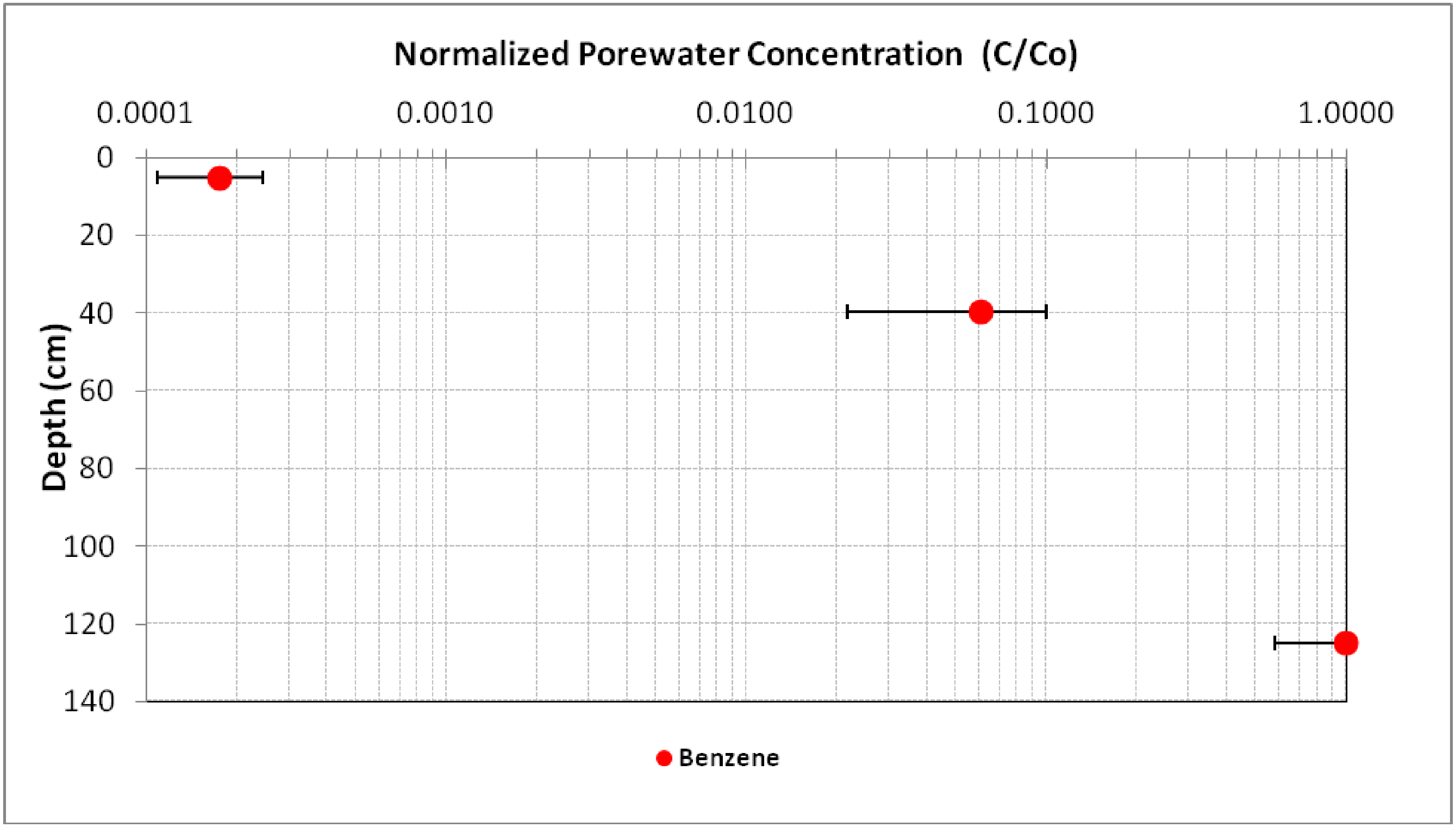


Figure 6.4-6
Benzene Calibration Results
Final Remedial Investigation, Quendall Terminals

ANCHOR QEA

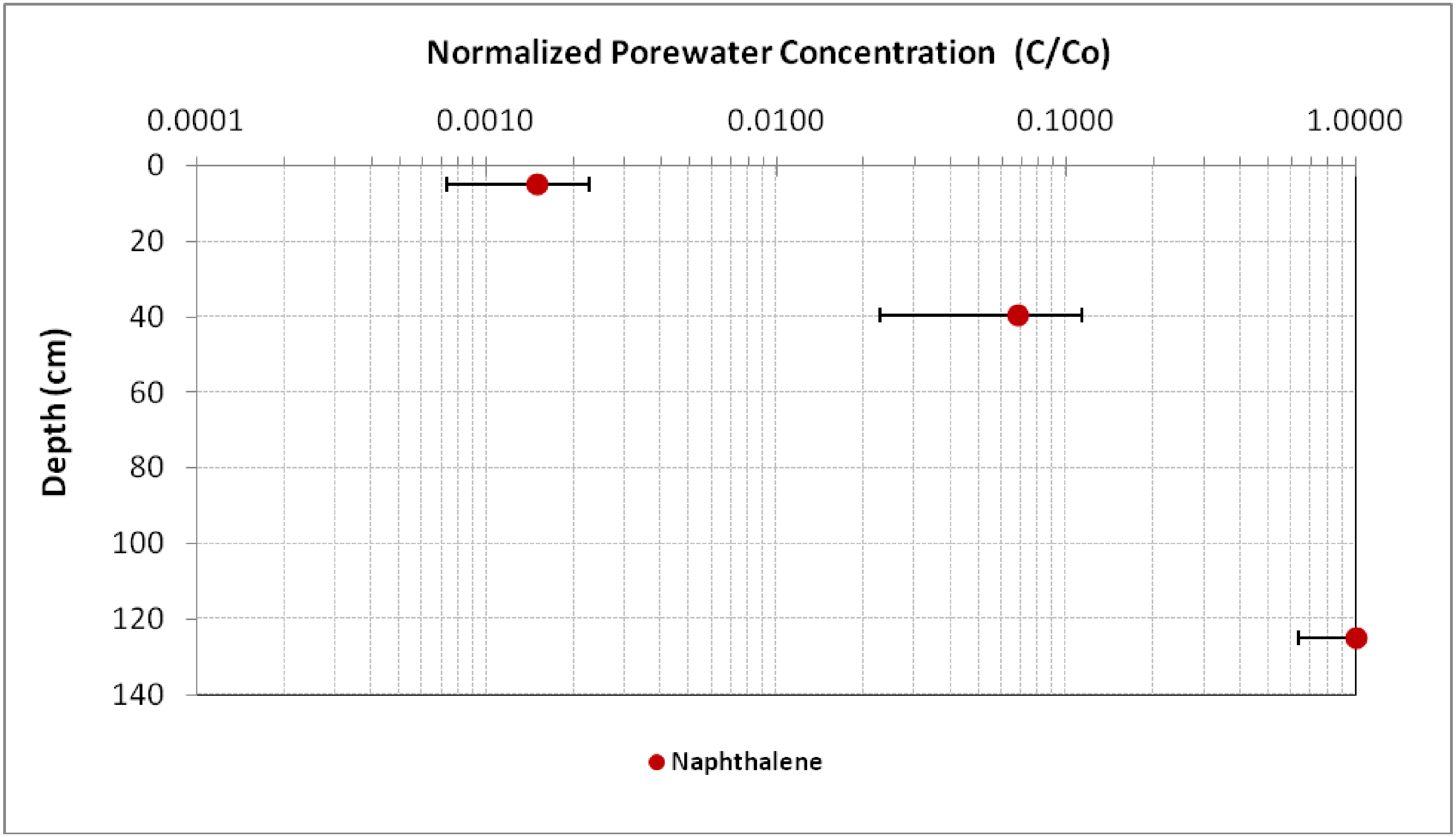
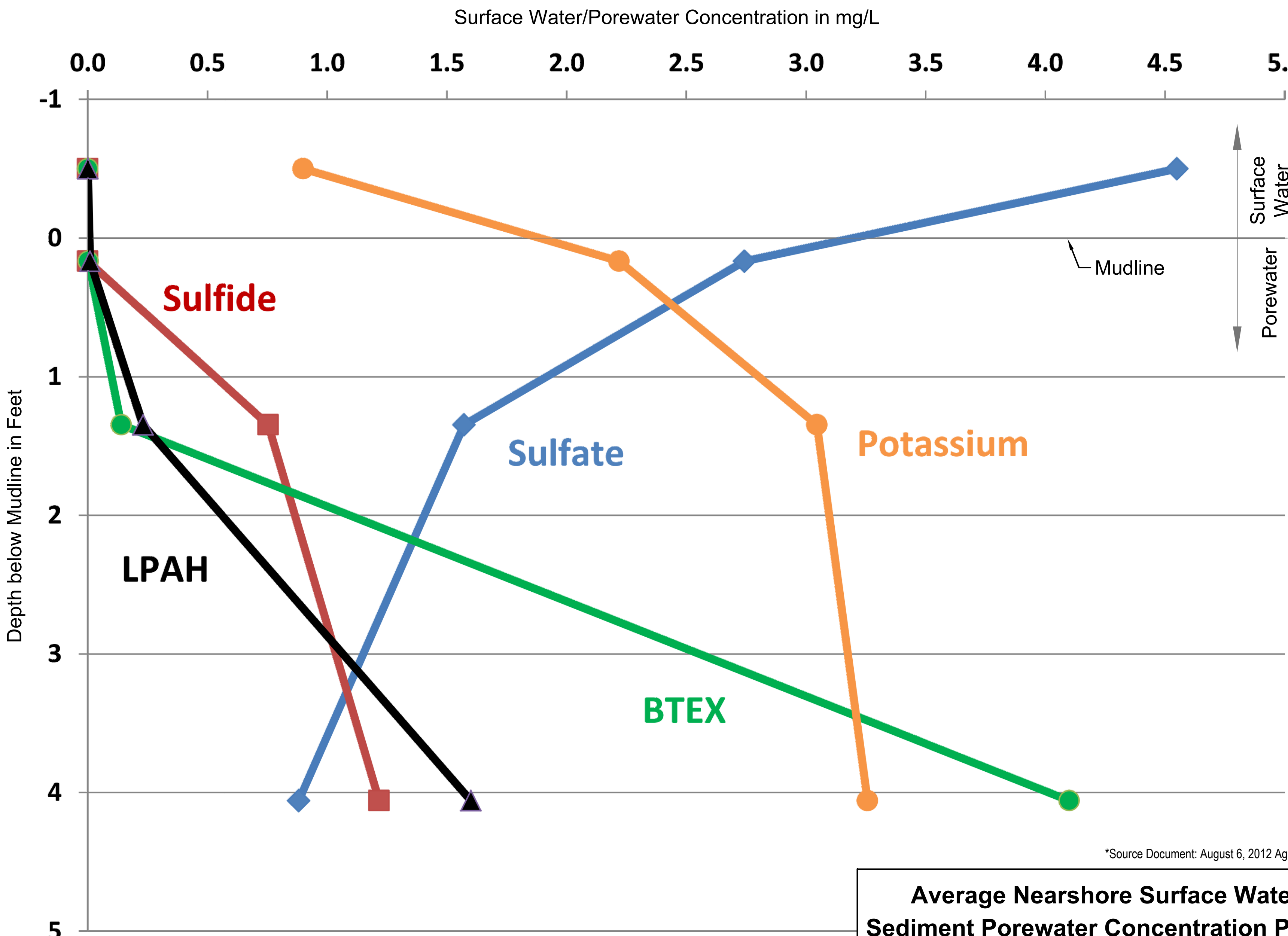


Figure 6.4-7
Naphthalene Calibration Results
[illegible] Remedial Investigation, Quendall Terminals



*Source Document: August 6, 2012 Agency Review Draft FS

Average Nearshore Surface Water and Sediment Porewater Concentration Profiles of Key Fate and Transport Constituents

Quendall Terminals Feasibility Study Report

Renton, Washington

Aspect CONSULTING	ANCHOR QEA	FIRM: ANCHOR QEA DRAWN BY: DJH	FIGURE NO. **3-14**